Waste Reduction Guide

Measuring Success
The Tennessee Study

TVA

CASE HISTORIES OF COST SAVING THROUGH WASTE REDUCTION BY INDUSTRIES IN TENNESSEE

A Joint Project of

University of Tennessee
Institute for Public Service
Center for Industrial Services

State of Tennessee
Department of Environment
and Conservation

Tennessee Valley Authority
Industrial Waste Reduction

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INTRODUCTION

Efforts by various levels of government to promote sound waste management and environmental protection--typically through laws and regulations--have often been less effective than desired and more costly to enforce than expected. Understandably, industry has often been more concerned about reducing compliance costs and their effects on profits than about reducing wastes and their effects on the environment. The threat of penalties has produced suspicion of inspections and assessments, resistance to almost any prescribed changes, and, at best, only grudging, minimal compliance with the letter of the law.

To address these problems and the unserved need they represent, the Tennessee Valley Authority (TVA) Waste Reduction Assessment and Technology Transfer program (WRATT), in cooperation with the Environmental Protection Agency (EPA), the University of North Carolina at Asheville, state agencies, and state university industrial extension programs, helped develop an approach generically known as waste reduction assistance (WRA).

The recognition the program has received in several national publications has resulted in many requests for TVA's WRATT program to assist state and local governments in developing and implementing similar WRA programs. Although the names vary widely from place to place, WRA programs have now been adopted in Region IV by the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. Outside the region, WRA programs have been adopted by Iowa, New Hampshire, Vermont, and the city of Los Angeles, California.

In contrast to regulation and enforcement, the WRA approach is based on voluntary cooperation. Only those industries that specifically request to participate in these joint projects receive waste management assessments. These assessments and their results are nonregulatory, nonbinding, and confidential. It is not the threat of enforcement penalties but the opportunity for significant cost savings that motivates industries to make any changes that may be suggested.

Assessments are specifically made outside the context of regulatory and enforcement processes, and the results are held strictly confidential to protect proprietary interests. The assessors do not express opinions or answer questions regarding compliance with state or federal regulations.

Industries are under no obligation to implement any of the suggested changes. However, most industries are not only willing but even eager to implement some or all of the changes recommended because they want to take advantage of the associated opportunities for cost savings.

Costs are kept low because most assessments are conducted by retired senior-level engineers, who are specially recruited and given intensive supplemental training in identifying and reporting opportunities for waste reduction. Although the retirees are

reimbursed for travel expenses and are paid a modest hourly honorarium to supplement their retirement income, they essentially volunteer their services as a means of passing on to the next generation the benefit of their specialized expertise and experience. Because the pool of available assessors contains specialists with many years of experience in almost every possible Standard Industrial Classification (SIC) Code it is usually possible to choose expertise that closely matches the needs of any particular industry. Because the pool is large, it is usually possible to reduce travel costs by selecting well-qualified retirees who live in the vicinity of almost any industry scheduled for assessment.

In most cases, the services of retirees are coordinated and administered under the oversight of nonprofit industrial extension programs at universities. For example, the Waste Reduction Assistance Program (WRAP) at the University of Tennessee Center for Industrial Services, under contract to the Tennessee Department of Environment and Conservation, coordinated the initial joint pilot WPA project in Tennessee, which is the subject of this case history report. While this approach has obvious benefits for private industries, it is also an effective and economical way for public agencies to accomplish their goals of reducing production of hazardous and other wastes while at the same time helping produce both environmental and economic benefits in the region, including such significant benefits as reduced needs for future waste disposal capacity and environmental effects monitoring.

This approach does not compete with private enterprise. Such assessments are not commonly available from private consulting firms in the region, nor would many small industries be likely to make the speculative investment of contracting for such services even if they were available, because the extent of any potential saving cannot be identified until after the survey has been completed.

On the other hand, the project may actually stimulate demand for commercial services. Assessments do not include designing or constructing any facilities or equipment that may be needed or modifying any processes or techniques as may be recommended. Industries must either implement the waste reduction suggestions on their own or contract with private consulting firms, construction contractors, or other commercial services.

TVA, EPA, and the eight states in EPA's Region IV pooled resources to fund the first waste reduction assistance pilot project, which was conducted in Tennessee beginning in 1989. That project consisted of assessments for 32 industries that volunteered to participate. The assessments identified opportunities for the annual reduction of 950 tons of hazardous waste, 600 tons of nonhazardous solid waste, and 680,000 gallons of wastewater.

Four years later, the industries involved in the pilot project were asked to provide information about their implementation of the assessment recommendations and about the results, in terms of both waste reduction and cost savings. Five of the 32 industries declined to participate or requested that their results remain completely confidential to

protect proprietary interests or for other reasons. The remaining 27 industries agreed to allow publication of their results only as anonymous case studies.

These 27 industries documented a combined annual saving of $2,380,626 (table 1) as a result of voluntary implementation of changes suggested by the assessments. Savings averaged $88,171 per industry per year.

In this pilot project, retirees conducted about 75% of the total assessment work; staff from the University of Tennessee Center for Industrial Services provided the remaining 25%. Therefore, the portion of the total annual saving for the 27 reporting industries that was attributable to retiree assessments was $1,785,500, or an average annual benefit of $66,130 per industry.
Retiree assessment costs are not available on a directly comparable basis for just the 27 reporting industries. However, the assessment services provided by retirees for all 32 industries that received assessments totalled $59,000, or an average cost of $1,844 per industry.

Even on that basis, if the resulting rate of saving had been realized for only a single year, there would be a 36:1 ratio between the average benefits and average costs for the pilot project (table 2 and figure 2). In other words, $36 was saved for every $1 spent on retiree-assisted assessments, including not only the direct costs for assessment time and associated travel reimbursement but also all the costs for program development, training, overhead, and reporting. In fact, however, the benefit:cost ratio is continually increasing, because the costs were one-time costs while incremental savings continue accumulating year after year.

TVA 8: MAGAZINE PRINTING

SIC Code: 2721

Assessment Summary:

The company prints magazines, catalogs, and newspaper inserts. In addition to waste reduction, recycling, or recovery programs already in place for paper, ink, pallets, and solvent, assessors suggested the following:

- Substitute well water for all process cooling water and lawn sprinkling to reduce potable water use and associated sewer charges. (Water use was four times normal.)

- Pretreat process wastewater to reduce chemical and biochemical oxygen demand below permit limits before discharging it to the municipal treatment plant to avoid a monthly surcharge.

- Use water-based detergent for cleaning most surfaces; use Varsol (petroleum naphtha) only for washing metal press parts. (A parts-cleaning station was rented for each printing press, and each station sump contained 25 gallons of Varsol. During each change-out, an estimated 15 gallons of Varsol was vaporized in the work areas.)
- Improve separation and recycling or paper, cardboard, and aluminum drink cans noted in trash receptacles.

- Install an ink mill to salvage waste ink and formulate an acceptable blend of recycled and new ink to save costs for purchasing new ink and disposing of waste ink.

Results:

- Sewer charges were reduced $10,000 annually.

- The number of Varsol stations was reduced from 43 to four, and cleanout frequency was increased from two to three weeks, saving $5,000 annually.

- Solid waste was reduced more than 75% through employee involvement and improved separation techniques for paper and pallets.

- An ink blending mill salvaged 90% of waste ink, saving an estimated $200,000 to $250,000 annually.

TVA 9: GREETING CARDS

SIC Code: 2771

Assessment Summary:

The company lithographs greeting cards and forms. Waste reduction suggestions included:

- Install a double block and bleed arrangement in the continuous piping system (which bypassed the centralized mixer directly to the sewer) to reduce the risk of isopropanol spills.

- Install a cartridge filter to remove 31,680 pounds of hazardous waste ink annually from wastewater, and recycle the ink to save $3,000 annually by eliminating disposal costs.

- Install a silver recovery unit to provide full control over this hazardous material and yield 100% of the value of the silver recovered from photographic processing solutions and wastewater and from proof prints and scrap film. (Although the company was contracting silver recovery, legal liability remained with the company.)

- Grind paper cores and sell the fiber for recycling instead of discarding it.

- Blend some of the 1,800 gallons of waste oil generated annually with fresh oil and recycle it to reduce costs and reduce the amount given to an offsite contractor.

- Reclaim the 31,200 pounds of waste ink generated annually (valued at $3.00 per pound) and blend it with virgin black ink to save $48,000 annually for purchase of new ink and removal and disposal of waste ink and drums.

Results:

- The use of isopropanol was eliminated.

- Volatile organic compound atmospheric emissions were reduced 180,000 pounds annually.

- Improved segregation of white paper, printed paper, and solid waste saved $8,000 annually by allowing use of the municipal solid waste disposal system instead of a private disposal service.

TVA 10: CONVEYOR SYSTEMS

SIC Code: 3535

Assessment Summary:

The company uses welding, forming, cleaning, painting and other processes to manufacture material handling systems (conveyors). Recommended changes included:

- Separate and recycle cardboard, paper, and scrap metal chips instead of landfilling them with mixed trash.

- Be aware that although fumes from welding vents were exempt from air pollution control permits, any that might emit a hazardous vapor, such as lead from a soldering operation, would require a permit.

- To reduce waste from conventional spray painting:
  - Limit overlap to 50%.
  - Keep the spray gun 6-8 inches from the work surface.
  - Keep the spray gun moving 250 feet per minute.
  - Hold the spray gun perpendicular to the work surface (angling it 45 degrees can cause 65 % overspray).
  - Use proper air pressure, which can reduce overspray by 40%.
  - Change to water-based paint, high-solids paint, or powder coating.

Results:

- Minimizing overspray and changing to water-based paint where possible:
  - Reduced paint purchase costs by $1,200 annually.
  - Reduced hazardous waste by 400 pounds annually and reduced associated disposal costs by $2,400 annually.
  - Reduced dried paint solids from overspray and reduced associated disposal costs ($320 per 55-gallon drum) by $3,960 annually.

TVA 11: ELECTROPLATING

SIC Code: 3471

Assessment Summary:

This job-shop electroplates items with chromium over nickel or with black chrome. Identified waste reduction opportunities included excessive use of rinse water on plating lines (18,000,000 gallons annually costing more than $70,000 annually) and excessive generation of hazardous metal sludge (costing $100,000 per year for treatment and disposal). Reduced water consumption would reduce requirements for treatment chemicals and sludge drying, reduce disposal costs, and increase potential marketability of sludge. Suggestions included:

- Increase drain times on manual lines when there is excess capacity.

- Install timing lights on critical tanks to pace operations (lights could be activated by a micro-switch as the rack is raised from the bath and remain lit for a fixed time).

- Use valves to restrict flow to 1 to 2 gallons per minute).

- Install a flow meter in a key location in each operating line to monitor water use.

- Reduce sludge generation by installing instruments for continuously monitoring pH and oxidation-reduction potential and for better controlling the flow rate, dwell time, and concentration of chemicals for the wastewater stream (more lime and sulfite than necessary were being used, resulting in excess costs for purchasing treatment chemicals, increased precipitation of sludge from neutralization of spent alkaline and acidic solutions, and excess cost for sludge disposal).

- Instead of paying for sludge disposal, market sludge to a recycler (the value of its metal content--especially the nickel--is rising); if necessary, dry it to the recycler's preferred moisture level to increase its marketability.

Results:

- Water consumption was reduced by 2,000,000 gallons annually, which reduced the $70,000 water and sewer costs by 12%, or $8,400 annually.
- Using two polymers instead of lime increased the cost for wastewater treatment chemicals, but that was offset by a 20% annual reduction in disposal costs and elimination of the need for 60,000 pounds of lime annually.

- Hazardous metal waste was reduced by 40,000 pounds annually, saving $6,400 annually in disposal costs.

TVA 12: VEHICLE SEATING

SIC Code: 3732, 2531

Assessment Summary:

Manufacture of boat, bus, and truck seats was releasing to the atmosphere each year 12,700 pounds of trichloroethylene degreaser and 8,300 pounds of toluene paint thinner, both hazardous wastes. Disposal of 16,000 cubic yards of corrugated wood pallets and 1,750 cubic yards of mixed metal stampings was costing $53,000 annually. Suggestions included:

- Use a water-based wash system instead of trichloroethylene.

- Use a water-based paint instead of lacquer to eliminate the need for toluene (estimated 2-year payback for a $300,000 capital outlay for a system for applying water-based paint).

- Improve solid waste reduction and recycling:
    - Separate and sell all corrugated cardboard.
    - Repair wood pallets for reuse if possible; chip those that are beyond repair and give away the wood chips to realize a possible cost avoidance of $11,000 instead of a disposal cost of $53,000.
    - In addition to the $47,000 already being gleaned from sale of other metal scrap, reclaim and sell the remaining 1,750 cubic yards of mixed metal scrap.
    - Combine waste reduction, reuse, and recycling to reduce waste hauling fees by 50% for a $26,000 annual saving.

Results:

- Installation of a water-based wash system and powder paint system eliminated use of trichloroethylene as a degreaser and toluene as a paint thinner.

- Hazardous waste was reduced 147,000 pounds annually, providing a cost savings of $50,000 annually.

- Solid waste disposal costs were reduced 75%, saving $45,000 annually.

- Raw material costs were reduced 10% annually.

TVA 14: POWER TOOLS

SIC Code: 3546

Assessment Summary:

The company processes raw materials into power tool components by stamping, machining, cleaning, oxide coating, and painting. Suggestions included:

- Use a water-based paint to eliminate the purchase, use, hazards, and disposal of thirty-six 55-gallon drums annually of paint thinner (nonhalogenated solvent, esters, and ketones, classified as F003 and F005) used to clean spray painting equipment.

- Clean parts in an existing water-based cleaning system to eliminate the purchase, use, hazards, and disposal of twenty 55-gallon drums annually of petroleum solvent (Varsol).

- Change to a black oxide coating bath that does not contain chromates and identify and eliminate sources of lead to reduce or eliminate hazardous heavy metals from sludge and reduce sludge generation by eight 55-gallon drums annually.

- Change from manual to automatic paint spraying to reduce overspraying and reduce dried paint waste by 50% or ten 55-gallon drums annually.

- Use only deionized water in phosphate baths to reduce phosphate sludge by 30% or nine 55-gallon drums annually.

- Investigate reclaiming cutting oil for reuse to reduce waste oil by 80% or 24,000 gallons annually.

Results:

- Hazardous waste decreased 35,000 pounds, saving $22,000 annually.

- Nonhazardous solid waste decreased 20,000 pounds, saving $500 annually.

- Disposal cost decreased $23,000 annually.

- Raw material cost decreased $7,000 annually.

- Labor cost decreased $10,000 annually.

- Material recovery savings increased $6,000 annually.

TVA 15: RUBBER VACUUM MOLDING

SIC Code: 3069

Assessment Summary:

Vacuum molding of rubber floor mats for the automotive industry weekly generates 26 truckloads of scrap rubber, 6 truckloads of pallets and cardboard, and six truckloads of paper bags. Of the 190,000 pounds of cured rubber trim scrap generated weekly, 50,000 pounds is milled into powder, half of which is sold and half of which is used in compounding, leaving 140,000 pounds or 20 truckloads (7,000 lb/truckload) to be landfilled weekly. Suggestions included:

- Reduce the sheet size of uncured calendared rubber by 2% to reduce cured rubber waste by 19,000 pounds weekly. Reduce waste rubber by 140,000 pounds weekly to 121,000 pounds weekly for a raw material saving of $0.25 per pound or $4,750 weekly and $247,000 annually.

- Trim the reduced-size sheets of uncured rubber to conform more closely to the molded shape to provide an additional 10,000 pounds per week of uncured trim for reuse and an additional weekly saving of $2,500 or annual saving of $130,000 while also reducing landfilling costs.

- Increase the use of cured hammermilled powder for compounding by 5,000 pounds weekly and increase powder sales by 5,000 pounds weekly to reduce landfilling by 10,000 pounds weekly for a net cost saving of $1,200 weekly or $62,000 annually.

Implementation of all three suggestions would save $439,000 annually and reduce landfilling of scrap by 2,000,000 pounds annually. Installation of a bulk storage system would eliminate all waste paper bags, in which mixing chemicals such as clay, sulfur, and calcium carbonate are received).

RESULTS:

Reduced-size sheets caused excessive loss of time in aligning molds. Internal use of powdered rubber scrap could not be increased, and it was cheaper at the time to buy raw material than to make powdered rubber.

TVA 16: AIRCRAFT PARTS

SIC Code: 3728

Assessment Summary:

Aircraft parts are manufactured by machining, sheet metal fabrication, and metal finishing. Metal finishing lines offered the greatest opportunities for waste reduction. Suggestions included:

- Install additional automatic control instruments (although timers and conductivity cells were already used to control rinse water lines, many controls were manual).

- Optimize time versus concentration on tanks equipped with timer controls.

- Reduce excess rinse water flows to reduce water and sewer charges and to reduce hydraulic loading on the wastewater treatment plant, which will increase its efficiency and reduce its batch operating time.

- Use drag-out pans between tanks to reduce contamination of rinse water and use of chemicals.

- Use the racks over each tank to provide more dwell time for draining solutions and rinse water.

- Consider using a plastic abrasive for paint stripping to eliminate the need for highly hazardous chromic and nitric acid chemical stripper.

Results:

- Hazardous waste was reduced 12,000 pounds annually, yielding a cost saving of $34,000 annually.

- Air emissions were reduced 9,300 pounds annually by reduced use of raw materials, yielding a cost saving of $31,000 annually.

TVA 17: OFFSET PRINTING

SIC Code: 2752

Assessment Summary:

This offset printing company already has advanced waste management programs for paper, pallets, water, silver, and aluminum. However, assessors noted that the company uses solvent for cleaning presses and landfills used ink kits that still hold residual ink (the inks cost $4/lb, and the company uses 40,000 pounds of ink annually from 5- and 25-pound kits). Suggestions included:

- Use a water-based cleaner instead of a solvent.
- Consider buying predominant colors of ink in bulk.
- Negotiate with the ink supplier to return, for credit if possible, used kits containing various amounts and colors of usable ink (to be blended with new ink into black—-the predominant ink used for printing) to reduce landfilling by 3,748 pounds annually.

Results:

- The company is still testing various water-based cleaners, looking for a substitute for solvent, but each cleaner tested so far has caused production problems and resulted in finished products that do not meet company standards.
- The ink supplier did not welcome residual ink for blending.
- Landfilling of residual ink was reduced 2,000 pounds annually through improved housekeeping in draining more ink from the kits before disposal and having this residue hauled offsite by a recycler. This resulted in saving $8,000 annually (2,000 lb at a cost of $4/lb for new ink).

TVA 18: FABRIC COATING

SIC Code: 2295

Assessment Summary:

The company coats or impregnates fabrics with vinyl and polyurethane for use in boot liners, shoe uppers, insulating jackets, and cap material. In 1989, use of 4,200 gallons of solvents contributed to atmospheric emissions of 300,000 pounds of volatile organic compounds (VOC). Recommendations included:

- Replace solvent-based cleaners with water-based substitutes.
- Replace solvent-based coatings with water-based coatings wherever possible.

Results:

A water-based coating was substituted for solvent coating, and "plastic sol," a material which is used to make vinyl and which can be recycled into the process, was substituted for solvent for cleaning pumps.

- VOC emissions were reduced 206,000 pounds annually.
- Hazardous material disposal cost was reduced $7,000 annually.
- Solid waste was reduced 31,000 pounds annually.
- Raw material cost savings totalled $13,000 annually.

TVA 19: METAL CABINETS

SIC Code: 3499

Assessment Summary:

Metal cabinet manufacture involves metal forming, welding, and painting and coating. Prolonged worker exposure to the highly volatile constituents of the paints used reportedly can cause serious health effects. Recommendations included:

- Use alternative coatings to reduce or eliminate use of solvent.
  - Water-based paints contain little or no organic solvent and require no solvent for cleanup.
  - Paints with high solids but low solvent content would probably meet corrosion resistance requirements.
  - Powder coating would eliminate the need for using solvents during coating.

- Substitute safer solvents.

- Recover solvent to reduce use and waste (investigate using a batch solvent still with 2- to 6-gallon per day capacity and 95- to 98-% recovery efficiency).

- Use multiple spray guns, one for each color, to avoid using solvent to clean a single gun when switching colors.

- Use improved spray techniques to reduce costs for paint, labor, electricity, maintenance, and solid waste disposal:
  - Limit overlap to 50%.
  - Keep the spray gun 6-8 inches from the work surface.
  - Keep the spray gun moving 250 feet per minute.
  - Hold the spray gun perpendicular to the work surface.
  - Trigger at the start and end of each stroke.

- Consider substituting electrostatic or high-volume low-pressure spraying instead of compressed air spraying at 40- to 60-psi, which is among the least efficient painting techniques.

Results:

- Most painting was contracted to an outside service that complies with all EPA regulations, and the company is now looking towards obtaining an electrostatic spraying system.
  - Solid waste was reduced 720 pounds annually, saving $720 annually.
  - Raw material costs were reduced $2,400 annually.
  - Labor costs were reduced $360 annually

TVA 20: AUTOMOBILE PRODUCTS

SIC Code: 3429

Assessment Summary:

Manufacture of automotive ignition, door, and trunk locks resulted in need for improved management of hazardous electroplating wastes, solvents, and hydraulic and cooling oils. Assessors offered the following suggestions:

- Reduce drag-out from electroplating tanks:
  - Provide counter-current flow and heat the plating baths so that evaporation provides room for returning drag-out to the tanks (requires extensive capital investment).
  - Increase drain time for plated parts (studies show 10 seconds of drain time reduces drag-out 80%).
  - Investigate racking parts to maximize drainage.
  - Use drain boards between tanks.
  - Investigate using the minimum concentration of metal in plating baths.
  - Investigate reducing surface tension with heat or a surfactant.

- Determine the metal content of electroplating sludge and sell it through an industrial waste exchange instead paying $26,000 annually to have dried sludge hauled away for disposal.

- Use a batch still (with an initial investment of $3,700 and a payback period of 6.5 months) to recover for reuse 90% of three waste solvents (6,700 pounds of trichloroethane contaminated with chromium and other metals, 2,660 pounds of used but contaminated trichloroethane, and 1,400 pounds of used petroleum naphtha), leaving only 10% to continue requiring disposal ($90 per drum), for an estimated annual savings of $6,798 (assuming $2.95 per gallon for new solvent versus $0.70 per gallon for operating the still).

- Sell 115 drums per year of waste hydraulic and cooling oils to potential buyers who recycle oil for fuel instead of paying a modest cost to dispose of these oils as nonhazardous waste.

Results:

Through process changes and improved housekeeping:

- Heavy metal wastes were reduced 80,000 pounds annually, saving $10,000 annually.

- Disposal costs were reduced 50%.

TVA 21: WOOD CABINETS

SIC Code: 2434

Assessment Summary:

Manufacture of wood cabinets in two plants resulted in an estimated 7,386 tons of scrap wood annually. Of this, 1,056 tons was used as supplemental fuel in plant 2 while 6,312 tons required removal and disposal at an average cost of $98,000 annually. Assessment resulted in the following recommendation:

- Purchase a second wood-fired boiler for plant 1 (with an estimated $229,000 capital cost and a 4-year payback period) to reduce the amount of wood waste requiring disposal by an additional 1,208 tons (saving $19,000 annually), and to reduce the cost of natural gas usage an estimated $77,000 annually for a total savings of $96,000 annually.

Results:

- Natural gas usage was eliminated in plant #1 by installing a "hammerhead hog" to grinds wood waste into chips for burning.
- Wood waste requiring landfilling was reduced 50% annually, for a cost saving of $49,000.
- Wood waste hauling costs were reduced 20% annually.
- Natural gas cost savings were negated by increasing landfill costs for the remaining wood waste.

TVA 22: HYDRAULIC HOSE

SIC Code: 3052

Assessment Summary:

Assessment of this manufacturer of rubber and thermoplastic hydraulic and industrial hoses focused on oil and grease in two water recycling systems and evaporation of hazardous solvent.

One water systems recycles cooling water, and the other recycles plant water and condensed steam; both pick up oil and grease, which are removed by manual skimming. Lubricant dissolved in 1,1,1, trichloroethane solvent drips continuously on mandrels in the hose-making machinery, and 120,000 pounds of this hazardous solvent evaporates into workplace environment at a cost of $55,000 annually. Suggestions included:

- Invest in a floating-tube oil skimming system (payback period less than one year), in which closed loops of flexible plastic tubing pick up oil, which is removed and collected as the tubes continuously pass through scrapers.

- Reduce employee exposure to trichloroethane, perhaps by capturing emissions with carbon absorption beds and using a solvent recovery system--a system to handle 1,000 cubic feet of air per minute and recover 85% of the 120,000 pounds of evaporated trichloroethane would cost $50,000 but would save $47,000 annually.

Results:

- The company controlled the mixture of hazardous and nonhazardous materials, improved the oil removal system in the water treatment plant, and changed to a water-based substitute for trichloroethane to dissolve lubricant.
  - Hazardous waste was reduced 29,000 pounds annually, saving $15,000 annually.
  - Disposal cost was reduced 20%.

TVA 23: PRINTING INK

SIC Code: 2893

Assessment Summary:

The company manufactures printing inks for gravure and flexographic printers; 75% of these inks are solvent based, and 25% are water based. Cleaning of batch drums and pigment mills when ink color is changed results in 7,480 gallons annually of solvent wash waste. If not recycled by blending into a darker ink, it is stored in 55-gallon drums on a diked concrete pad to await disposal, which costs $8,840 annually. Water wash waste from the ink blending and wash water solvent cleanup processes, which--although it has never been analyzed as "hazardous"--contains heavy metal pigments, is also stored there in drums to await disposal, which costs $6,630 annually. Water used to cool pigment grinding mills, which constitutes 85% of the plant's water and sewer charge of $11,140 annually, is discharged to the sanitary sewer after one pass through the cooling jacket, even though the temperature of the water entering the sewer is the same as that required for cooling the grinding mill. Suggestions for waste reduction included:

- Assuming that 50% of the solvent wash waste is nonrecoverable sludge, install a system to recover the remaining 3,740 gallons of solvent to save an estimated $17,510 annually in disposal costs and new solvent purchase costs.

- Install a large storage tank in which solids can settle from water wash waste. Once or twice a year, remove and dispose of the settled sludge, decant the clarified liquid into a drum sparged with air to remove volatile organic compounds (VOCs), and check the pH and neutralize it with lime if necessary before discharging the clarified liquid gradually to the sewer to save an estimated $5,970 annually in disposal costs (assuming a 90% reduction in the volume of waste requiring disposal).

- Install a cooling water recirculation system, with a water-chilling unit and a heat-sensitive valve for purging the system when it reached a given temperature, to reduce water and sewer use charges 75% and save $8,360 annually.

Results:

Suggestions stimulated changes in processes, procedures, equipment, and materials and produced cost savings:

- Disposal costs were reduced $1,800 annually.

- Raw materials costs were reduced $1,200 annually.

- Wash water and mill flush water are reused in blended ink.

- Even though it does not clean batch drums and pigment mills as well, isopropyl acetate was substituted for N-propyl acetate because it allowed more compatible reuse of solvent waste in blended ink.

- Installation of an ink splitter and a wastewater treatment system reduced wastewater sludge.

- Installation of a cooling water recirculation system is still under consideration.

TVA 24: SCREW MACHINE PRODUCTS

SIC code: 3451

Assessment Summary:

This company, which manufactures automotive screw machine products (needle valves and high-compression hose fittings), was concerned about waste reduction in degreasing operations, which use kerosene to wash large amounts of cutting oil and trimmings from parts between operations and before final cleaning in trichloroethane.

Waste kerosene is mixed with waste cutting oil, without depressing the flash point below 140 degrees Fahrenheit, and a total of 900 gallons of this mixed waste oil is annually hauled offsite for disposal. About 1,600 pounds annually of hazardous bottoms from the trichloroethane recovery still is hauled offsite for recycling. Of greater concern to assessors were 6,000 pounds annually of point emissions and 25,000 pounds annually of fugitive emissions of trichloroethane into the workplace environment. These were addressed by the following recommendations:

- Limit the rate at which baskets containing components are lowered into and raised from trichloroethane degreasers to 11 feet per minute to minimize turbulence in the vapor layer and avoid drag-out of solvent.

- Bring components up to temperature before removing them from trichloroethane degreasers to ensure that the cleaning cycle is complete (no condensation is still forming) and to reduce drag-out.

- Use the automatic degreaser, which is a closed system with fewer fugitive losses, in preference to the manual degreaser.

- If the manual degreaser must be used, install a sliding cover to minimize solvent losses.

- For optimum trichloroethane recovery, dispose of still bottoms when they reach an oil level of 60 to 70 percent, which can be determined by measuring their boiling temperature.

Results:

The company reported that although some procedures were difficult to control, the suggested changes seemed to have improved their operations by reducing waste per unit volume of work; however, results were difficult to quantify because their volume of work had increased.

TVA 27, 28: SPEAKER ENCLOSURES

SIC Code: 3651

Assessment Summary:

Manufacture of small speaker enclosures involves primarily wood working (cutting drilling, and routing medium density particle board with a vinyl overlay) and assembly (reinforcing corners with hot glue and applying water-based paint to exposed edges). Sawdust and cardboard were the principal wastes from the company's two plants. About 40% of the sawdust is captured by a centralized vacuum system with hose ports at various work stations and is given to local farmers and gardeners for use as a soil amendment. The remaining 60% becomes airborne, settles, is collected by sweeping, and along with other trash, including cardboard at one plant, is landfilled by a private contractor in a private landfill at a cost of $960 annually. The cardboard waste from the other plant goes to the city landfill. The company has been unable to find a recycler willing to pick up their small volume of cardboard (only one bale monthly).

Neither sawdust nor cardboard disposal is costly or considered a severe problem. However, it would be environmentally desirable to reduce landfilling as much as possible, and costs may rise if the city requires that all waste generated in the city limits must be disposed of in the city's landfill and requires special waste containers for the sawdust.

Assessors suggested the following:

- Install additional plug-in hose ports so that all sawdust can be collected by vacuuming and given away as a soil amendment rather than landfilled.

- As an alternative, consider pelletizing sawdust for use as fuel.

- Continue trying to find a recycler to pick up cardboard.

Results:

- All sawdust is being collected and given to a local farmer to reduce soil erosion, and the $960 disposal cost has been eliminated.

- The company still has not been able to arrange for cardboard recycling.

TVA 29: ELECTRIC POWER DISTRIBUTOR

SIC Code: 4911

Assessment Summary:

This distributor, which buys electric power and distributes it to residential and commercial customers, operates a transport center and two service centers where vehicles are serviced and meters and transformers are repaired. Recommendations included:

- Investigate the economics of onsite recycling of 200 gallons per year of waste antifreeze to avoid environmentally undesirable disposal into the sanitary sewer.

- Evaluate and if possible reduce the frequency with which three parts cleaning stations are serviced by an industrial solvent company (presently on a fixed 4-week schedule) to reduce costs and hazardous waste.

- Send all obsolete meters from the two service centers to the transport center to increase the volume of disposal at one location and thereby increase leverage for negotiating disposal costs and ensuring compliance with the company's disposal policy.

- Wash strong alkali degreaser from tools into a sink draining to the sanitary sewer instead of onto the asphalt driveway at the tool repair shop.

Results:

The recommendations were not implemented.

TVA 31: ORE FUSING

SIC Code: 3295

Assessment Summary:

Heating in an electric furnace fuses magnesite ore into electric grade and refractory grade magnesium oxide. As part of the finishing process metal fines derived from the ore or from finishing equipment are removed magnetically and landfilled. Some magnesia product is unintentionally removed in the process. Recommendations included:

- Separate magnesia from waste fines, recycle the magnesia into the process, and market the other metal fines, along with other metal scrap, for recycling.

- Segregate waste paper, aluminum, and metal straps from trash and market them for recycling.

Results:

- Use of a different magnet removed less magnesia during removal of metal fines:
  - Solid waste was reduced 1,010,000 pounds annually, saving $2,019 annually.
  - Raw material needs were reduced, saving $177,000 annually.

TVA 33: BICYCLE SEATS

SIC Code: 3751

Assessment Summary:

The manufacture of bicycle seats and infant seats involves metal forming, electrostatic spray painting, metal cleaning, and stripping operations. Recommendations included:

- Measure flows to find how best to reduce water use (100,000 gallons/day of process water, 60,000 gallons/day of cooling water), increase residence and settling in the 3-lagoon treatment system, and reduce maintenance costs ($300,000 to empty, dredge, and dispose of sludge from the first lagoon).

- Use only powder spraying or change from solvent-based to water-based paint to reduce hazardous solvent waste (DOO1 and FOO3) and atmospheric emissions of volatile organic compounds (VOCs, which are near the permit level of 100 tons annually) to qualify as a "small quantity generator."

- If wet painting continues, install a 15- to 30-gallon still to recover and recycle onsite 95% of the solvent used to clean paint lines when changing colors, with a 1-year payback and $11,000 annual cost saving (solvent purchase costs and offsite recycling and disposal costs for 6,063 gallons of D001 hazardous waste solvent the previous year totalled $15,000, compared to a still operating cost of $4,000 annually).

- Track sources of steel scrap (1,660 tons the previous year, or a scrap rate of 8.5%), evaluate and reduce waste for each department and machine, and avoid waste by specifying hardness, metal chemistry, and dimensional tolerances in material purchase orders (reducing the scrap rate to 7.5% would save $90,000 annually).

- Ask the vendor to specify objective criteria such as chemical testing instead of subjective judgments of appearance and odor as a basis for scheduling replacement of an oil-and-water emulsion to help reduce the volume and cost of disposing of 3,500 gallons annually.

Results:

- Recirculating cooling water saved 20,000 gallons daily.
- Using only powder painting reduced VOC emissions 75,000 tons annually and saved $15,000 annually.
- Hazardous waste was reduced 30,000 pounds annually.

- Disposal cost savings totaled $4,000 annually.

TVA 34: AIRCRAFT REPAIR

SIC Code: 7699

Assessment Summary:

Helicopter service and repair involves everything from a simple oil change through a complete engine tear down to stripping and repainting. Recommendations included:

- Install a system to filter dirt, grease, and carbon from degreasing solvent (330 gallons now used annually cost $5,470, including disposal) to double its life and save $2,735.

- Use on-off spray nozzles instead of letting the hose run continuously to reduce water use for rinsing engine parts after paint stripping (to qualify as a "small quantity generator," the present 175 gallons per month of contaminated rinse water must be reduced more than 65%).

- Filter the water used for rinsing airframes after paint stripping, hold it in a storage tank, and reuse it for initial rinses, using fresh water only for the final rinse (filters would require disposal as hazardous waste, and tanks would require semiannual pump out and disposal; however, gross savings could be as high as $16,000 annually, and the firm would qualify as a "small quantity generator").

- For the long term, evaluate alkaline and biodegradable cleaners as substitutes for phenol and methylene chloride cleaners.

Results:

- The recommended solvent filtering system was installed:
  - Hazardous waste was reduced 7,000 pounds annually.
  - Disposal cost was reduced $3,000 annually.
  - Raw material purchase cost was reduced $1,500 annually.

TVA 35: CARPET YARN SPINNING
SIC Code: 2281

Assessment Summary:
This yarn spinning mill annually spins 233,000 bales of fiber into nylon carpet yarns. Opportunities to reduce landfilling of plastic wrap and steel strapping were identified:

- Segregate and sell for recycling the polyethylene plastic wrap that covers incoming bales of fiber.

- Segregate, chop into small segments, store in drums, and sell for recycling the steel strapping that ties bales of incoming fiber into units.

Results:
- A recycler hauls away, without charge or payment, 24 tons of plastic wrap annually, saving $432 in disposal costs.

- A recycler buys more than 72 tons of steel strapping annually ($1 per hundredweight) and hauls it offsite, without charge, for recycling, providing a return of $1,450 annually.

Other changes, although not addressed by the assessment, emerged from the enhanced awareness of waste reduction opportunities stimulated by the assessment:

- A recycler now hauls away, without charge, waste oils for recycling, eliminating the disposal cost of $2,500 annually.

- To reduce emissions from the use of coal as a fuel, the company converted to gas and now enjoys "pipeline rates".

TVA 36: RUBBER AND VINYL STRIPS

SIC Code: 3069

Assessment Summary:

This company manufactures rubber and vinyl automotive weather strips and seals. Suggestions included:

- Protect incoming raw material from contamination during storage and handling to reduce waste due to defective material and to reduce landfilling.

- Control feed rate and speed on extrusion lines to reduce waste and to reduce landfilling.

- Set up a program to categorize and measure extrusion wastes by cause (defective material, setup, tooling change, defective extrusions, end-run pieces) so that solutions can be devised.

- Prepare lacquers and glues in large, master batches, but add curing agents (hazardous solvents such as toluene and methyl ethyl ketone) only at the point of use to activate only the quantity than can be used before exceeding the "pot life" of the mixture (this would reduce hazardous waste, raw material cost, recordkeeping, and disposal cost.

- Combine small production runs to meet several closely related "just in time" shipping release dates for various automotive customers (reduced costs for startup and shutdown wastes will more than offset handling costs for increased inventory of in-process and finished products).

- Arrange to eliminate the $14.00 monthly fee for an unused water meter.

Results:

No results were reported for suggestions based on the assessment; however, other changes not addressed by the assessment emerged from the enhanced awareness of waste reduction opportunities stimulated by the assessment:

- The company is installing a cardboard compactor and baler to reduce landfill waste.

- The company further reduced by $1,800 annually the cost of removing wood pallets (which were being hauled away at no charge at the time of the assessment) by changing to the "Jack Daniels Program."

TVA 37: HOSPITAL

SIC Code: 8062

Assessment Summary:

Two general hospitals and a mental health facility comprise an 814-bed medical center with good waste reduction programs already in place. Additional suggestions included:

- Take a more active management role to ensure that recyclers collect aluminum cans and paper according to a timely schedule to prevent untidiness in "Recycling Center" rooms and to prevent discouragement of participating employees.

- Bale cardboard and sell it to a recycler (an offsite warehouse already recycles some cardboard) to reduce loading of the trash compactor, hauling frequency, and disposal costs.

- Order the trash compactor dumpster hauled to the landfill only when it is full rather than on a daily schedule (look inside or check the ram's hydraulic pressure to determine need).

- Establish timetables for support people to ensure that the existing waste management plan is implemented effectively and on time.

Results:

- Aluminum cans are now being collected at the various sites where the waste is generated rather than in central "Recycling Center" rooms.
  - Schedules for timely pickup and recycling are being met.
  - Collection areas are neat.
  - Personnel are participating in keeping the program active.

- Hauling the compactor dumpster only when it is full rather than daily eliminated one pickup per week and saved 5% of the disposal cost, or $15,600 annually.

TVA 40: AIRCRAFT COMPONENTS

SIC Code: 3728

Assessment Summary:

This company, which manufactures aircraft wing assemblies and subassemblies, had 50 waste streams when first assessed. Recommendations in an earlier report resulted in changes in processing, materials, equipment, and housekeeping that reduced waste and costs (reported under "Results"). To eliminate hazardous waste disposal costs of $42,000 annually and avoid compliance problems (Clean Air Act Amendments mandated phasing out trichloroethane and imposed increasingly higher excise taxes on this product beginning in 1991), the company requested further help in identifying a water-based substitute (as suggested in an earlier report) for the trichloroethane solvent used in degreasing. Supplemental recommendations included:

- Continue testing an alkaline cleaner showing promising results as a substitute for trichloroethane for manual wipedown.

- Convert three trichloroethane vapor degreasing tanks to a suggested water-based cleaner, confirmed feasible by the company's engineering staff, but proceed cautiously to minimize conversion costs and ensure continued compliance with customers' quality requirements.

Results:

- Over four years (1988-1991), hazardous waste was reduced 4,000,000 pounds, saving $350,000, or $87,500 annually.

- Over two years (1990-1991), solid waste was reduced 9,500,000 pounds, saving $41,000, or $20,500 annually.

- Over two years (1990-1991), wastewater was reduced 10,925,000 gallons, saving $138,200, or $69,100 annually.

- Over two years (1990-1991), water consumption was reduced 7,675,000 gallons, saving $94,200, or $47,100 annually.

- Over four years (1988-1991), air emissions were reduced 211,800 pounds, saving $95,300, or, $23,825 annually.

- Disposal costs were reduced $500,000 annually.

- Raw material costs were reduced $200,000 annually.

- Utility costs were reduced $300,000 annually.

- Material recovery costs were reduced $50,000 annually.

TVA 41: AIRBASE SUPPORT SERVICES

SIC Code: 8744

Assessment Summary:

The environmental engineer for this airbase support group requested a waste reduction assessment of specific waste streams. Recommendations included:

- Chemically treat the seldom-used 50-gallon chrome plating tanks, when they are cleaned once every five years, to reduce the chromium from hexavalent to trivalent.

- Add a small degreaser or ultrasonic cleaner for small parts and shut down the very large perchloroethylene degreaser (housed in its own building), except for occasional startup to clean large equipment, to eliminate loss of 50 gallons of perchloroethylene every two weeks due to evaporation from the uncovered vat and to drag-out during parts removal.

- Install a metal- or plastic-panel roof on an existing structural steel framework used for handling equipment in the "open air" pickling vats for mild steel and stainless steel to avoid dilution of the vat mixture by precipitation (it would also shelter the workers).

- Start a recycling program, beginning in the area where 130 families of military personnel reside, to reduce the 91 cubic yards of trash landfilled weekly (83 cubic yards from residences and 8 cubic yards from recreational facilities).

- If possible, reuse the nonhazardous slag product used as grit for paint stripping instead of purchasing new material (192,000 pounds were purchased during the previous 10 months), using it only once, and then landfilling it.

- As has already been done at three of the four cleaning stations in the test gun projectile laboratory, convert the fourth station from trichloroethane to an alternative cleaner.
- For internal machining, use an emulsifiable, water-soluble mineral cutting oil instead of petroleum oil with a metal deactivator.

- Consider using a storage tank and compressor to recover and reuse hydrogen after use as a transmitter in the projectile laboratory, rather than trapping it in a large container and allowing it to escape slowly to the atmosphere.

- Investigate substituting HFC-134 for R-12 refrigerant in the refrigeration unit at the projectile laboratory; in the meantime, schedule preventive maintenance and use a halogen or similar detection device to monitor for leaks at flanges, pump seals, valves, and the condenser to reduce excessive annual loss of 50,000 pounds of freon to the atmosphere and avoid the replacement cost of $160,000 annually.

- By 1995 HFC-134A refrigerant, which does not appreciably affect ozone depletion or deteriorate rubber seals, will be used instead of freon in the refrigeration units at the wind tunnels; until then, improve preventive maintenance to reduce the excessive annual loss of 110,000 pounds of freon to the atmosphere and avoid the replacement cost of $432,000 annually:
  - Improve leak testing with better instruments.
  - Improve pump and compressor seals.
  - Reduce vibration, which causes leak in solder joints on cooling coils.
  - Repair or replace cooling coils, which contribute more than 40% or 44,000 pounds to the annual freon loss.

Results:
A waste reduction program was recently initiated, concentrating first on recycling solid waste:

- To date, recycling of metals, cardboard, and high-grade white office paper has reduced solid waste 2,972,000 pounds annually with a return of $250,000 annually.

- Information about hazardous waste reduction is not yet available.

Table 1. Documented Annual Savings for TVA Funded Waste Reduction Projects in Tennessee, 1989-1992

TVA Project No.	Documented Annual Savings ($)
8	240,000
9	8,000
10	7,560
11	14,800
12	95,000
14	68,500
15	0
16	65,000
17	8,000
18	20,000
19	3,480
20	10,000
21	49,000
22	15,000
23	3,000
24	0
27,28	960
29	0
31	179,019
33	19,000
34	4,500
35	4,382
36	1,800
37	15,600
40	1,298,025
41	250,000
27 projects	2,380,626

No data was available for 5 projects

Table 2. Benefit: Cost Analysis For TVA Funded Retiree-Assisted Waste Reduction Assessments

Given:

Total cost of retirees for 32 audits = $59,000

Total documented annual savings for 27 audits = $2,380,626

Fraction of audit work done by retirees = ¾

Results:

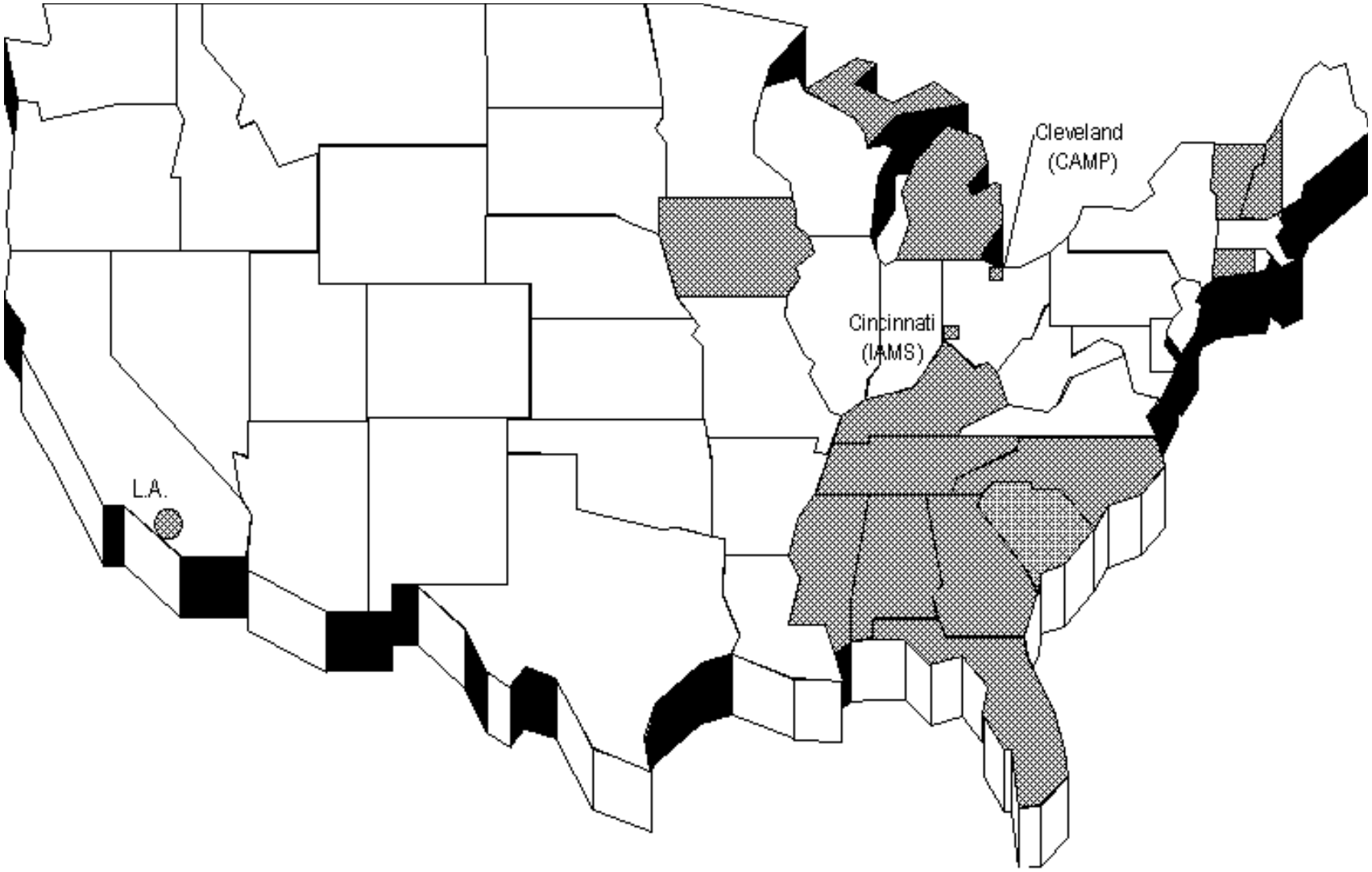
$2,380,626/27 audits = $88,171 average annual benefit/audit

$88,171 average annual benefit/audit x 0.75 audit/benefit from retirees =$66,129

$59,000/32 audits = $1,844 average retiree cost/audit

$66,129 average annual benefit from retiree/$1,844 average direct retiree cost
= benefit/cost ratio = 36 to 1

Figure 1. Waste Reduction Programs with Retiree Assistance



AVERAGE ANNUAL BENEFIT:COST RATIO

36:1

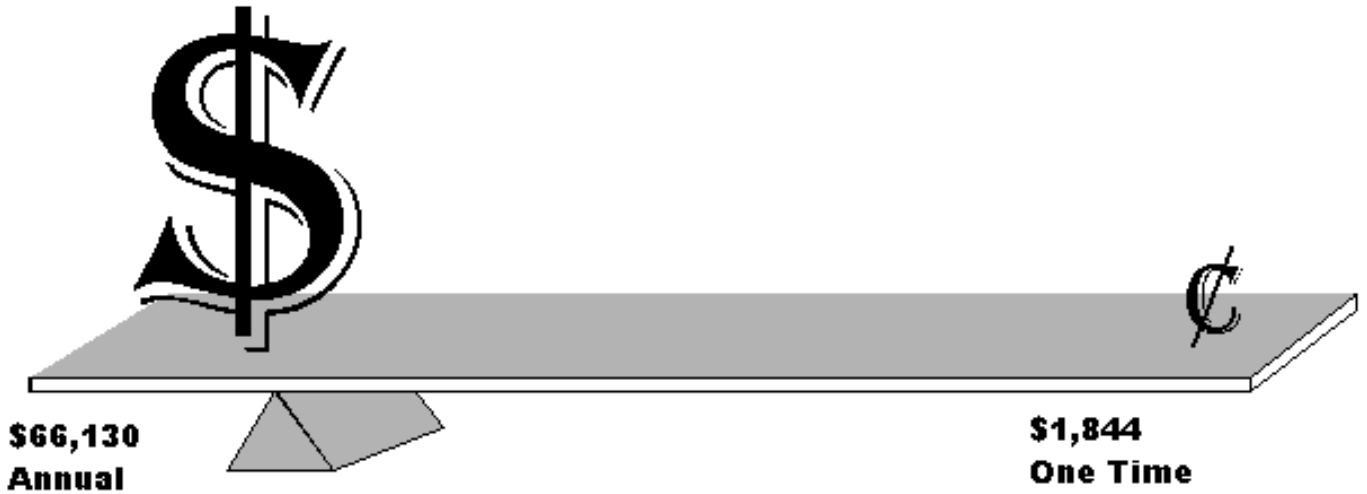
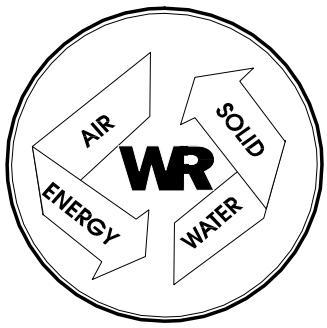


Figure 2. Average Annual Benefit:Cost Ratio For TVA Funded Retiree Assisted Waste Reduction Assessment Program In Tennessee 1989 - 1992

The publishers of this document would especially like to thank Bill Uhtenwoldt, a retired engineer working through UT-CIS, and Don Rucker, a technical reports writer with TVA for their efforts in making it happen.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